ances in position in some combinations, it is probable that a definite and approximately equal share of space must be accorded to each electron. The approximately rectilinear curve points to this fact. Both properties, however, differ somewhat in different combinations, so that some slight modification is to be understood. It is, however, sufficiently interesting to be able to trace such a relation when it is considered that neither the atomic volumes nor refractions can be directly measured, but are derived constants.

Some of the variations seem to point to variable relations with the ethereal medium. Negative anomalies, for example, are at present incomprehensible, the whole of the atomic refractions of, say, oxygen in $P(OEt)_3$, for example, disappearing entirely. Some of the *per saltum* changes are equally difficult to explain. The periodic relationship between the elements points rather to a spiral arrangement (understood in a solid sense)[2] of the electrons than to a series of rings. This arrangement is due to the fact that the spiral is one of the natural modes of motion of the æther and discrete particles immersed in it. This is shown in the case of spiral nebulæ. The vortex is another condition. Gradual disintegration of the atoms is thus more easily understood, and devolution is reversed evolution.

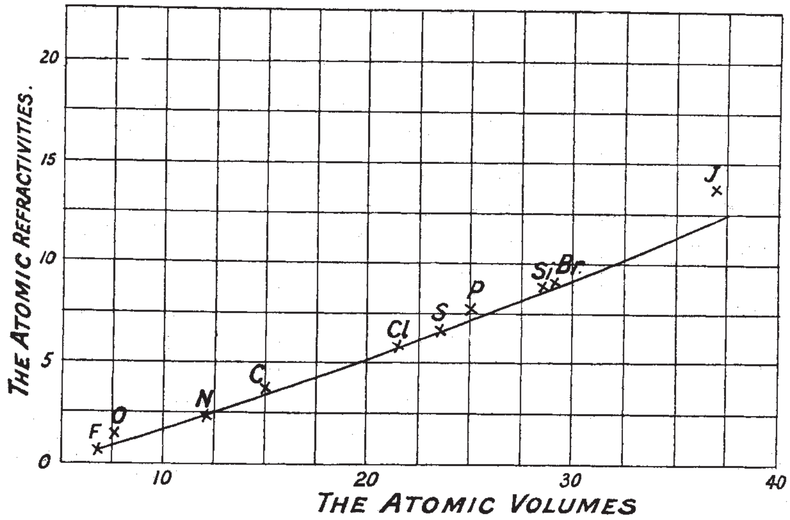

FIG. 1.—A relation between the atomic volumes and the atomic refractivities.

Up to the present the charge on the electron is regarded as static, but the existence of magnetic properties suggests rotations of electricity on the material particles. This would result in a magnetic flux. It, however, seems to be impossible to distinguish the charges within the atom.

Note.—A numerical relation with the atomic masses suggests itself. $m=3r_a \times F$, F being a factor probably representing concentration of matter (atomic density).

$m=b_0 \times F$ b_0 for A.Z.

$\frac{m}{b_0}=F(2, 2, 3, 3)$ not for first series except for C.

Cl 6×3×2= 36
Mn 8·8×3×2= 52·8 (55)
Br 8·8×3×3= 79·2 (79·6)
I 13·9×3×3=125·1 (126).

F diminishes from group 7 to 4 and increases differently in the groups. This relation is, however, based on products, whilst the additive cumulative factor is evident; still, the relation is interesting. The next homologue after Cl is Br (red liquid). There is, however, a large gap between the two. Instead of an easily condensible yellow-red vapour at 55, by some twist we get a metal. There is a similar disparity between Br and I. GERVAISE LE BAS.

6 Springfield Crescent, St. Heliers, Jersey.

Hybridity and the Evolution of Species.

As the author of the "Theory of Evolution by Means of Hybridisation," I am naturally much interested in the recent papers by Dr. Harrison and Miss Blackburn, which proved beyond any reasonable doubt that most British rose-species are of hybrid origin, though this was not suspected. The authors based their conclusion that hybridity is one of the prime factors in the evolution of species, if not the only one, on their cytological results, which agree with those of Tackholm on a much larger number of rose-species from all parts of the world. The reviewer of their papers in NATURE of September 15, p. 99, does full justice to the importance of these results, and directs attention to Jeffrey's work tending to show that the presence of "bad pollen" is proof of a hybrid origin—a view much strengthened by Brainerd and Petersen's study of the New England *Rubi* (Vermont Agric. Expt. Sta. Bull. No. 217), in the course of which they find much hybridisation and no forms with entirely good pollen.

To this view the reviewer takes exception. That "bad pollen" is unsafe as a criterion of hybridity is shown, he says, however, by other results. As such he considers the fact that isolated species, such as the Californian *Trillium giganteum,* the nearest relative of which is in the Eastern States, possess a certain amount of bad pollen. I am sorry to say that I fail to see the bearing of a now isolated habitat on the problem in question. I suppose that the reviewer will agree with me that the origin of *Oenothera biennis,* which for several centuries has been a feature of the flora of the dunes in many European countries originated elsewhere than in Europe; so why should *Trillium giganteum,* and *Dirca occidentalis* and *Scoliopus Bigelovii,* the other two species with bad pollen which he quotes as proof of his contention, have originated at the spots they now occupy? And if they originated somewhere else, the argument against their possible origin by crossing does not hold good.

Velp, Holland, October 4. J. P. LOTSY.

IT is perhaps only natural that Dr. Lotsy should take a special view of any facts that bear on his theory of evolution by hybridisation, but in the above letter he is clearly begging the question. In the article on British roses and hybridity to which he refers it was pointed out that the original authors did not consider *all* British roses to be hybrids, but looked upon the diploid forms and the Pimpinellifoliæ as pure species. In such cases as Trillium, Dirca, and Scoliopus, it is not sufficient for him to suggest that they must be hybrids merely because they have bad pollen. The fact, previously cited, that

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[2] A spherical *tourbouillon* with a vortical centre and a peripheral rotation (model slip-knot).

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pollen sterility and fertility behave as a pair of characters in the sweet pea and the velvet bean should in itself be sufficient to give pause to those who would like to regard bad pollen as a proof of hybridity. The theory of mutation equally requires the occurrence of a certain proportion of defective germ cells.

The Hagedoorns, in their recent book on "The Relative Value of the Processes Causing Evolution," also support the idea of the origin of species by crossing, but are obliged to admit that loss mutations must occur, though why they should confine themselves to loss mutations is not clear. It will be necessary to bring some more convincing argument in support of hybridisation as a constructive evolutionary factor before it is likely to receive much serious consideration from biologists.

The Writer of the Article.

A System of Space-Time Co-ordinates.

The common instruments of measurement proposed in theory and employed in practice for the co-ordination of physical events consist of rigid bars and clocks. The limitations of such methods are obvious. The erection of a rigid bar for the direct determination of the distance of the moon from the earth is inconceivable from a practical point of view, while it is a gross absurdity to speak of the measurement of molecular distances by means of rigid bodies. There is only one type of connecting-link across space suitable for co-ordination of events, namely, the light-ray. I here define a system of space-time co-ordinates which involve only one metrical quantity, the vibration period of an atom.

Let there be a vibrating atom at A emitting light-rays. The *time* at A is read from the atom there. Let P be any other particle, which sends back instantaneously to A the light-rays arriving from A. Let a ray start from A at time t' and return to A at time t''. If an event occurs at P at the instant of the arrival of the said ray, we shall define two of the co-ordinates of the event as

$$\begin{aligned} \textit{distance of event from } A = x_1 &= \tfrac{1}{2}(t''-t'), \\ \textit{time of event} = x_4 &= \tfrac{1}{2}(t''+t'), \end{aligned}$$

the expressions in italics being defined by these statements.

Let B and C be two particles such that x_1 is constant with respect to time for each of them. Let a light-ray be emitted from B and return to B after reflection from C. The departure from B and return to B of this ray are two events at B, and we have already defined the time of events occurring at B. Let the ray leave B at time x'_4 and return to B at time x''_4. Let C be so situated that $(x''_4-x'_4)$ is constant for all successive rays.

A, B, and C constitute the frame of co-ordinates. For sake of example, we may observe that three of the corners of a rigid rectangular block at rest in a terrestrial laboratory satisfy the conditions imposed on A, B, and C, so far as our experimental accuracy can ascertain; whether they would continue to do so if the block was rapidly revolved about an axis is a matter for experiment to decide.

We have now three particles, A, B, and C, and from our definitions we can write down the time of an event occurring at any of the three. Let any event P occur. Let it coincide with the arrival of a light-ray from A which left A at t'_A and returns to A at t''_A and with the arrival of a ray from B which left B a t'_B and returns to B at t''_B, and also with the arrival o a ray from C which left C at t'_C and returns to C at t''_C. We define the four co-ordinates of the event P by the equations:—

$$\begin{aligned} x_1 &= \tfrac{1}{2}(t''_A - t'_A) \\ x_2 &= \tfrac{1}{2}(t''_B - t'_B) \\ x_3 &= \tfrac{1}{2}(t''_C - t'_C) \\ x_4 &= \tfrac{1}{2}(t''_A + t'_A). \end{aligned}$$

It is to be observed that this co-ordinate system, although from the method of definition applicable to the most general gravitational fields, will, in the absence of such fields, give the same values for the co-ordinates of an event as those obtained by rigid body measurements from three points of a rigid body and by a system of clocks.

J. L. Synge.

Department of Mathematics, University of
Toronto, Toronto, Canada, September 16.

Aeroplane Photography for Archæology.

Photographs from an aeroplane taken on a clear afternoon a little before sunset would give good records of ancient British and Roman camps, "castles," villages, rings, pack-tracks, barrows, ditches, and other earthworks, and, as in such photographs taken in Mesopotamia, would probably reveal details that cannot be distinguished by inspection on the ground. Photographs might yield almost as much information as the models in the Pitt Rivers Museum at Farnham, which were made from laborious contour surveying.

There are hundreds of such earthworks on Salisbury Plain, and many of them are, no doubt, related to Stonehenge and to Avebury. The stereoscopic combination of two successive photographs might disclose those parts of the banks and ditches which are nearly obliterated by the village of Avebury. General modelling is wanted rather than fine detail. Perhaps such work might be done by learners.

A. P. Trotter.

Greystones, Teffont, Salisbury, October 12.

Cosmic Friction: A Query.

Writing with proper deference, I would ask astronomers whether it is not feasible to consider that the solar system may occasionally journey through a region of space occupied by exceedingly diffuse matter? Under such conditions the exceptional appearance of a large meteorite outside the earth's atmosphere might be possible; and some minute shortening of the period of a quickly revolving satellite, like the moon, might show itself by a cumulative advance of position. Contrariwise, if ever (say between 1865 and 1871) we passed through regions altogether free from even such evanescent friction, a readily affected comet, like Encke's, might temporarily recover from its usual perturbation.

Oliver Lodge.

Muscular Piezo-electricity?

There is a remarkable similarity between the structure of those organs of electric eels which are generally held to be the source of their "shocks" and the structure of certain artificially grown crystals exhibiting the piezo-electric property. Is it possible that there is a connection between the two, and that these creatures do produce piezo-electricity by the contraction of these organs? I should be interested to know if any of your readers have found any connection between these two phenomena.

E. Wriothesley Russell.

Trinity College, Cambridge, October 10.

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